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Nanotechnology in Science and Art

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Disclaimer

The burgeoning field of nanotechnology opens windows between science and art. Exploration of this interplay encourages interaction between scientists, artists and educators alike. The image below serves as an example of the fertile ground for exchange.

The substrate that this image captures is made of silicon, the material from which computer chips are made. A thin (~1 nm thick) chemical coating was applied homogeneously to the silicon. Specific regions of the coating, 600 nm wide (approximately 150 times smaller than the diameter of a human hair), were then locally removed from the silicon via photocatalytic nanolithography (PCNL(Bearinger, Hiddessen et al. 2005)). PCNL engages light, such as from a light emitting diode or an ultraviolet source, to activate molecules that are attached to a transparent mask above the silicon substrate. These molecules can be compounds similar to chlorophyll, the photoactive material that aids plants in photosynthesis, or may be semiconductor materials, such as TiO_2. Once these molecules are activated, chemical reactions result in local destruction of the coating on the silicon. Thus, only regions of the coated silicon in close contact with mask are affected. A non-fouling polymer hydrogel (~10 nm thick) was then grafted to the retained coating.

Hydrogels are superabsorbent and are therefore used on the bulk scale in common items including contact lenses and diapers. They also find utility in topical drug delivery and tissue engineering applications. Because the hydrogel is so absorbent, exposing the silicon chip with patterned hydrogel to water vapor from one's breath reveals the pattern that the lithography dictates(Lopez, Biebuyck et al. 1993). The myriad of colors seen in the image are due to optical interference. The thickness of the swollen layer determines the colors that are visible. While the field of view immediately following hydration appears like a big drop of oil shining in the sun, the oil drop appearance breaks up into many small domains as the water vapor evaporates. The base silicon does not retain the waterin the same way that the way the hydrogel does, due to differences in surface tension. Thus, the pattern stands out from the background.

In addition to bringing together nanotechnology, polymer chemistry, materials science and optics, this image suggests imposing order to an otherwise chaotic world. This is a repeated theme in nature across multiple orders of magnitude. The interface of this order and chaos is amorphous, and render a Klimt-like vision of reflected light. As this image is just a still in time, it also reminds us that all things and states are transient and that the materials of the earth, just as we individuals, are constantly evolving.

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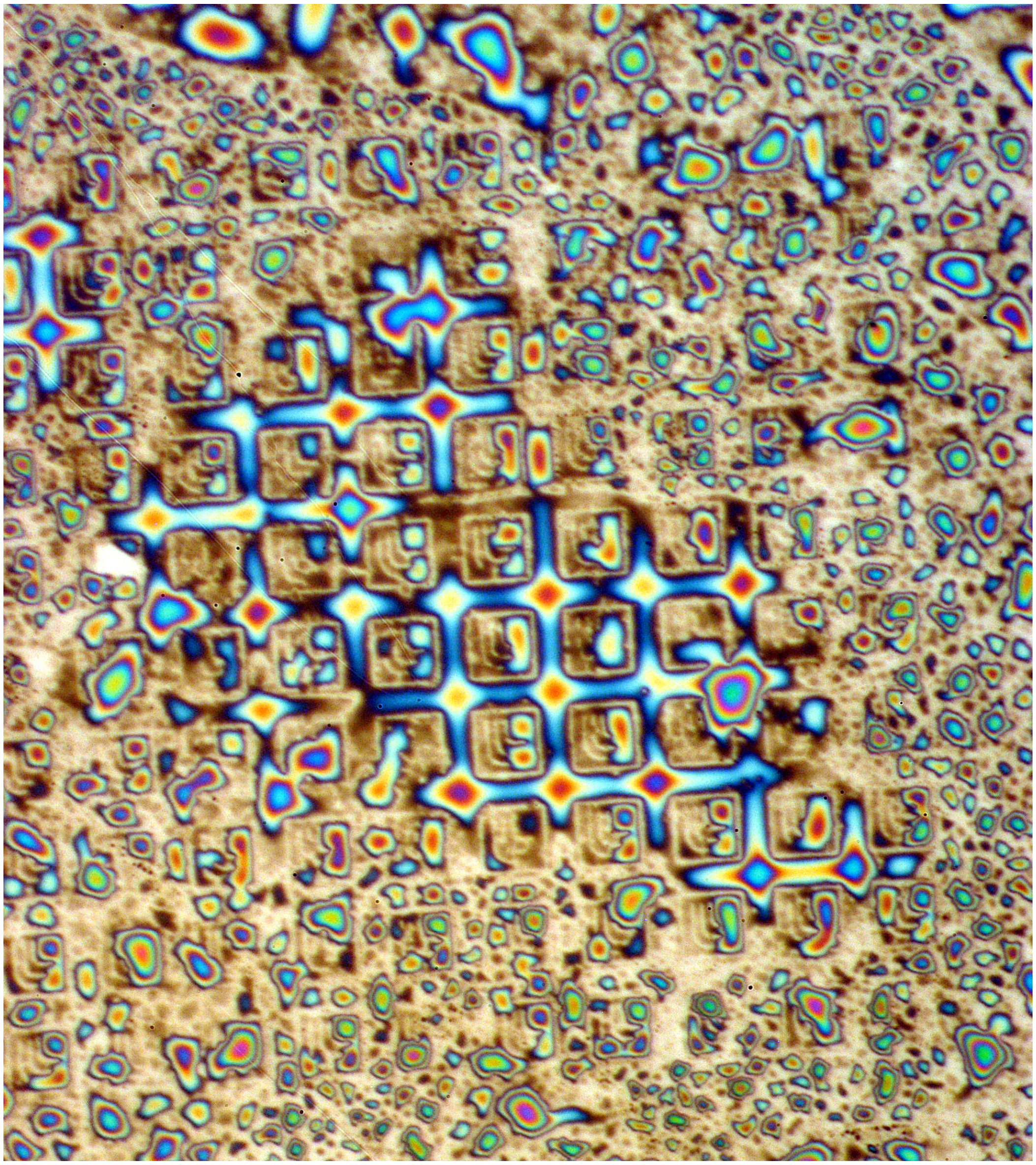

Figure Caption:
This image was acquired optically with a Nikon D100 camera mounted on a reflectance-based Nikon Labophot 2 microscope. The pattern (modeled after the Lawrence Livermore National Laboratory logo) appears only upon exposure to vapor which hydrates the ~10nm thick polymer. Line patterning was performed before photoinitiated polymerization via photocatalytic nanolithography.
Line width ~600 nm, feature height = 100 μm tall, feature depth = 10 nm.

References:
Bearinger, J. P., A. L. Hiddessen, et al. (2005). Biomolecular patterning via photocatalytic lithography. NSTI Nanotech 2005, Anaheim, CA.

Lopez, G. P., H. A. Biebuyck, et al. (1993). "Imaging of Features on Surfaces by Condensation Figures." Science **260**(5108): 647-649.